5130-91
ONLY

N94-16303

p. 2

THE DISTRIBUTION OF LARGE VOLCANOES ON VENUS AS A FUNCTION OF HEIGHT AND ALTITUDE; S.T. Keddie and J.W. Head, Brown University

Introduction: Theory predicts that the slower cooling of lava flows on Venus should result in lava flows that are typically 20% longer than their terrestrial counterparts [1] and that the development of neutral buoyancy zones (NBZ) on Venus may be strongly influenced by altitude-controlled variations in surface pressure [2]. Observations that support these predictions would include relatively low heights for Venus volcanoes (discussed with pre-Magellan data by [3]), and an increase in both the number and development of large edifices with increasing basal altitude. We present the results of an analysis of the height and altitude distribution of 123 large (diameter >100 km) volcanoes made using Magellan image and altimetry data and we use these results to begin to test the predications of the above theories.

Height of large volcanoes: The height of a volcano was determined by taking the difference between the altitude of the highest point on the edifice and the average altitude of the plains at the distal reaches of flows from the edifice. The mean height of 123 large volcanoes on Venus was found to be 1.42 km (Figure 1), less than the heights of many terrestrial volcanoes, which are often a few kilometers high [4] and, in the case of Hawaii, as much as 8 km high [3] This low height results in a low mean slope for these volcanoes of less than one degree.

Altitude distribution of large volcanoes: If the bases of large volcanoes were evenly distributed as a function of elevation, they would be found in the skewed, unimodal distribution shown by the dark columns ('expected') in Figure 2. The actual distribution, however, shown in the observed category, shows a slight paucity of volcanoes at the extreme elevations and an enhancement in the number of edifices in the mid-altitudes. Chi-square tests of the data reveal that the two data sets are different at the 95% confidence level and that the deviations from the expected distribution are most pronounced in the mid-altitudes (more volcanoes than expected) and, to a lesser degree, in the lowlands (fewer volcanoes).

Height as a function of altitude: Although the majority of volcanoes cluster between basal altitudes of 6051-6053 km and at heights of <3 km, there is a weak correlation (R=0.55) of volcano height with basal altitude. Volcanoes that occur at the greatest elevations in general reach the greatest heights.

Discussion: The generally low heights of venusian volcanoes are consistent with the prediction that lava flows on Venus would be relatively long; the further a given volume of lava flows from its source, the thinner the flow will be and thus the less height it will contribute to a growing shield. Calculations of flow volumes may make it possible to estimate the degree to which this lengthening of flows has influenced volcano heights. There is a weak correlation of edifice height with basal altitude; the highest volcanoes occur at the greatest altitudes. These tall volcanoes, such as Maat Mons, are also quite well-developed; many flow episodes, of often significantly variable radar properties, hint at a long and complex history of volcanism [5]. Thus to a first order, there appears to be some evidence for the positive correlation of edifice development and topography predicted by Head and Wilson [2]. The distribution of large volcanoes as a function of altitude also supports these predictions. Poor or no development of a NBZ in the lowlands would inhibit edifice growth and promote flood and channel-type eruptions (illustrated by the paucity of low-altitude volcanoes in figure 2 and the prevalence of flood deposits and channels at this altitude range [6,7]). Early development of NBZ's at relatively shallow depths and enhanced magma production associated with local mantle upwelling at small regional rises would encourage growth and development of edifices at the mid-altitudes (illustrated by the greater-than-expected number of volcanoes in this altitude range in figure 2). The predicted

deepening of magma reservoirs with altitude suggests that larger magma reservoirs should form and that edifices should be common and well developed (illustrated by the relatively greater heights reached by volcanoes at high basal altitudes in figure 2 and the complexity of high-altitude volcanoes like Maat Mons).

Although to a first order the observed distribution of volcanoes on Venus as a function of altitude and height can be quite nicely explained by theoretical considerations, there are many factors that will influence the location of volcanoes on the above figures: age of a volcano; magma supply; thermal gradient and mantle dynamics; terrain type; burial by large flows; and possible changes in the intrusion to extrusion ratio of magma. Further consideration of these and other factors will result in a better understanding of the reasons for the distribution of large volcanoes on Venus.

References: [1] Head, J.W., and Wilson, L., 1986, JGR, 91, pp. 9407-9446; [2] Head, J.W., and Wilson, l., 1992, JGR, 97, pp. 3877-3903; [3] Schaber, G.G., 1991, PLPSC XXI, pp. 3-11; [4] McClelland, L., et al. (Ed.), 1989, Global Volcanism 1975-1985, 655 p.; [5] Keddie, S.T., and Head, J.W., 1992, LPSC XXIII, pp. 669-670; [6] Baker, V.R., et al., 1992, JGR, 97 E8 pp. 13421-13444; [7] Head J.W., et al., 1992, JGR, 97 E8, pp. 13153-13197.

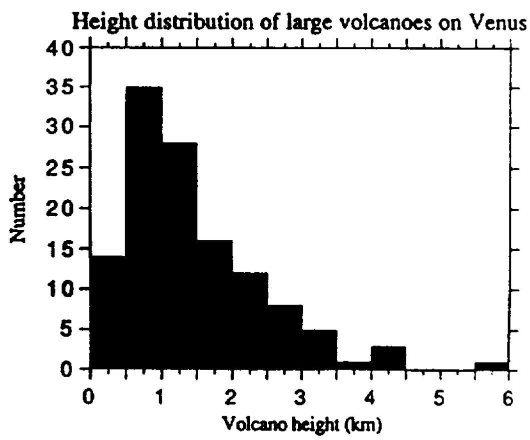

Fig. 1: Histogram of heights of large volcanoes on Venus. See text for method of calculating heights.

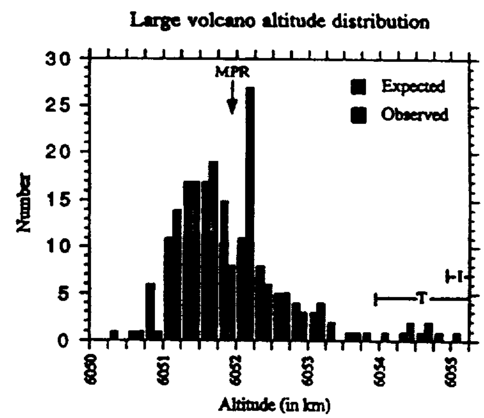

Fig. 2: Histogram showing location of the base of large volcanoes. 250 m altitude bins. 'MPR' is mean planetary radius, 'T' and 'I' indicate approximate altitude range for tessera and Ishtar Terra respectively. See text for a discussion of 'expected' vs. 'observed' categories.

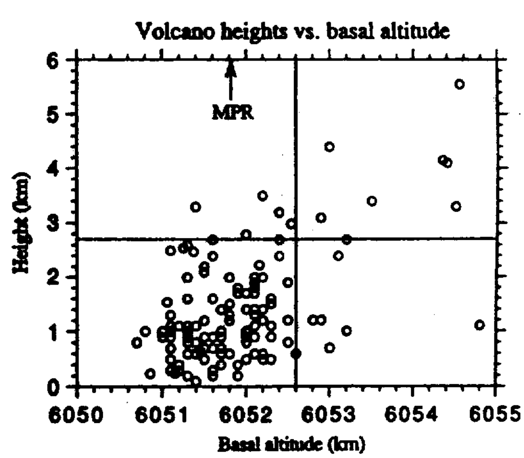

Fig. 3: Height of large volcanoes as a function of the altitude of the base of the volcano. Mean planetary radius (MPR) is indicated.